OPINION

Fisheries and Hard Rock Mining: AFS Symposium Synopsis

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The 2011 annual AFS meeting in Seattle included a one-day Fisheries and Hard Rock Mining symposium (sponsored by Trout Unlimited, the Pebble Limited Partnership, and the AFS Water Quality Section) that covered diverse topics and disciplines, including aquatic ecology, copper toxicity, mine waste mitigation, and mining regulation. Because of widespread concerns about the potential effects of mining on fisheries, we provide a brief synopsis of the session for *Fisheries* readers.

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Five talks focused on the effects of metal mines on aquatic ecosystems. In several case studies from North and South America, mine effects led to increased incidence of diatom structural anomalies and percent tolerant individuals; decreased diatom and macroinvertebrate taxa richness, biofilm, and fish percent intolerant individuals; and altered fish, macroinvertebrate, and diatom assemblage structure at local and catchment scales. Another study concluded that metal contamination of streams remains in the mining district in Idaho's N.F. Coeur D'Alene River Basin more than 100 years after mining began; even where metal concentrations are below water quality standards, poor physical habitat structure, elevated sediment levels, and high temperatures still limit fisheries. Researchers in Canada found otolith microchemistry was useful for evaluating the extent of metal contamination and the locations and timing of fish migration. Two presenters discussed the Bristol Bay drainage of Alaska, where 12 million acres of state land were reclassified by state government from habitat and recreation uses to a mining use despite a high water table, waters of low acid neutralizing capacity, active geologic faults, and salmonid presence in 75% of headwater streams surveyed (159 stream km). Because of those environmental conditions, development of the proposed Pebble Mine — a 10.8 billion ton copper (Cu) prospect in the Bristol Bay drainage — could threaten the world's largest, most valuable sockeye salmon fishery and the people who depend on salmon for income and subsistence.

Five presenters discussed Cu toxicity to salmonids and water quality criteria. In addition to impairing gill function, Cu can be acutely toxic through effects on the peripheral nervous system (e.g., olfaction, lateral line). For example, in low ionic-strength water, olfactory inhibition occurs as low as 2 ppb above background, and 70% olfactory inhibition occurs after 10 minutes at 10 µg Cu/L (ppb). A 1-h exposure to 44 µg Cu/L caused significant loss of olfactory neurons and Cu avoidance response by juvenile Chinook salmon. If they can, fish will avoid exposure to copper. However, detection of copper is (likely) chemosensory; fish no longer avoid copper after exposure to copper at concentrations and durations that are neurotoxic to the peripheral system of fish, potentially affecting their ability to reproduce, feed, avoid predators, and migrate. Water chemistry has an important influence on Cu bioavailability and toxicity. In particular, increasing dissolved organic carbon (DOC) concentrations can provide protection against olfactory impairment. One presenter showed instances where the USEPA's biotic ligand model (BLM)-based criterion for Cu, which incorporates a number of water quality variables (temperature, pH, alkalinity, DOC, and the major inorganic cations and anions), was more consistently protective against olfactory impairment in salmonids than hardness-based Cu criteria using 20% inhibition concentrations (IC20s) and published fish toxicity studies. Salmonid olfaction was not impaired below BLM-based Cu criteria in this study. Only a few states are currently considering use of the BLM to derive regulatory criteria for Cu. Hardness-based criteria were sometimes deemed under-protective or over-protective, depending on water hardness.

Mine waste mitigation and disposal was the focus of ten speakers. A 2009 U.S. Supreme Court decision upheld the disposal of Kensington Mine tailings into a lake in Alaska. Schedule 2 in Canada exempted water bodies from Fisheries Act protections. The cost savings of using a natural lake for waste disposal will likely lead to increased use of lakes for such purposes in both countries. In both nations, there is a need to limit such practices to clean fill and to isolate mine wastes hydrologically from ground and surface waters. The Fraser River basin has a 150 y history of mining, with 50 active mines; mitigation procedures focus on separating tailings and mines from waters, subaqueous waste disposal, and tailings covers. Careful planning for mine closure can mitigate fisheries impacts.

Capture and treatment of natural (pre-mining), metal-laden surface waters, coupled with isolation and treatment of mining effluents has decreased metal concentrations and allowed salmonid range expansion in Red Dog Creek, Alaska; however perpetual, costly treatment and maintenance will be required to maintain this condition in perpetuity. Removal of the Milltown Dam, Montana (driven by both public health and ecological impacts), cost at least $106 M, took 7 years, and resulted in the removal of a dam/reservoir and 2.2 M cubic yards of contaminated sediments; further rehabilitation and redevelopment is estimated to raise the costs to $150 M. Rehabilitation of the S.F. Coeur d'Alene River Basin is estimated to cost $1 B. Although abandoned mines may have substantial negative environmental and economic legacies, similar problems have been identified at some active mines. Water quality at mining sites is often worse than that predicted in environmental impact statements and environmental assessments. Water quality standards/criteria were exceeded at 74% of mines analyzed in one study, and at 93% of mines with close proximity to groundwater and moderate to high contaminant leaching potential. Acid drainage occurred at 36% of mines studied, yet 89% of the pre-mining assessments for those mines predicted that acid drainage would not occur. Water quality exceedances are associated with inadequate pre-mining hydrologic and geochemical characterization and failures in the performance of installed mitigation measures. Another study concluded that the major limiting factors for fishes at an Arizona mine were inadequate flows caused by excessive water withdrawals and naturally variable flows. Approximately 40% of western USA headwaters are affected by abandoned hard rock mines. However, there are insufficient funds for mine clean-ups, especially if effluents are non-toxic (e.g., excess sediments and temperature, inadequate flows, and physical habitat structure) and if salmonids are not potentially present. Mitigation is more successful if the entire ecosystem is considered and involves diverse stakeholders.

Legal and educational issues were discussed by three speakers. A two-day course on mining-fisheries conflicts and resolutions presented at an annual miners' convention in Alaska drew considerable interest by — and thoughtful exchanges from — miners, indicating the value of public education on mining issues. Legal liability is a major hindrance to reclaiming abandoned mines. Under current laws, a second party assumes liability for the site when it implements rehabilitation or restoration. Legislation to provide Good Samaritan protections for conservation groups interested in mine clean-up could aid in the rehabilitation of abandoned mine lands. The USEPA ability to regulate and remediate mine wastes is limited under the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), which established Superfund. Funding for Superfund is no longer provided through taxes on industries; rather, it is provided by uncertain Congressional appropriations, and the burdens of cleanup are borne by taxpayers rather than pollution-producing industries—although some mining companies do pay for cleanups themselves. One solution proposed is for mine owners to post bonds sufficient to cover the true costs of potential human and ecological liabilities resulting from mining, although these are extremely difficult to accurately estimate in advance. Additional work by USEPA directed toward clean-up and compliance includes new mining regulations, guidance documents, and permit restrictions concerning mine waste disposal.

In light of the information presented in Seattle regarding Fisheries and Hard Rock Mining, we recommend a number of policy changes to hard rock mining law and regulations, though not all the session participants might agree with every recommendation. Those include:

- Establish clear environmental standards, including biological use designations; quantitative chemical, physical, and biological criteria; and quantitative engineering standards with appropriate safety factors.
- Fund increased research on chronic metal toxicity, and evaluation and improvement of mitigation measures.
- Allow federal land managers to balance mining with other uses of public lands rather than giving primacy to mining.
- Designate sensitive lands and waters as off-limits to hardrock exploration and development.
- Restore fish and wildlife habitat to pre-mining or reference conditions, or incorporate compensation into estimates of financial assurance.
- Prohibit mines likely to result in perpetual water pollution and/or requiring perpetual water treatment.
- Prohibit mine discharges to surface or ground waters that degrade water quality.
- Improve mine oversight, monitoring, and enforcement of regulations.
- Increase pre-mining financial responsibility of permittees.
- Create funds and Good Samaritan legislation to aid clean-up of abandoned mines.
- Increase education of miners concerning the potential effects of mining on terrestrial and aquatic life, and methods for mitigation.

See also: the Op-Ed piece written by Robert M. Hughes (AFS First Vice President) and Carol Ann Woody that ran in The New York Times: www.nytimes.com/2012/01/12/opinion/a-mining-law-whose-time-has-passed.html